THE TRANSACTIONS

OF THE

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SOME SCIENTIFIC RESULTS OF A MISSION TO SOUTH AFRICA,

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Your country of South Africa has been heaved up from the sea by a great compressing force, coming from the south, in consequence of which all the older rocks come to the surface of the country towards the southern shores. These older rocks, owing to the intense pressure to which they have been subjected, have become folded, and heated by conversion of the mechanical pressure into heat; so that the water, which they originally contained, has slowly, during the long past ages, dissolved a very large part, if not the whole, of the substance of the rocks, in consequence of which these rocks have crystallised and acquired a new texture, totally different from that which they originally possessed, when laid down as sediments at the bottom of an ocean. In my survey of the country I have necessarily omitted the most ancient and most altered rocks, which lie upon the extreme south of the Colony, and my object has been to study the region which we know as the Great Karoo, and accordingly my attention was directed in the first place to the range of mountains which lie to the south of them, and which we know as the Great Zwartberg Range. These rocks I traversed, under the guidance of Mr. Thomas Bain, who made the Zwartberg Pass road, and having gone along the northern side of the mountains and observed the strongly-inclined condition of the top and of the strata, I passed along the southern side of the mountains, and came up in the Oudtshoorn district, by Schoeman's Poort, through Meiring's Poort, which carries the Olifant's River to the southward, and there I saw the wonderful structure of this range, and admired the rocks, folded in complex folds, turned up on end, and pointing upward and downward, again and again, due south, in three grand schemes of contortion; so that as the range spreads out, it consists of a comparatively moderate thickness of rock, repeated over and over again, owing to the manner

in which the rocks have been crushed together laterally by this intense power coming from the south. And when I had passed through this range (where I found the ancient limestones completely crystallised, limestones which themselves have been worn into pebbles and laid down as sure deposits, cemented into marble, which pebbles had acquired crystalline structure,) then upon these marbles I found altered rocks, ancient clays greatly altered, now converted into the condition of cleaved slates by the pressure, and upon this sandstone, rested and changed into quartzite, stones formed of pebbles in the same way, rolled down ancient shores, which pebbles were themselves bound together by a cement, formed in consequence of the intense heat, due to the process of compression. I then turned towards the rocks in the Prince Albert region, to those newer rocks which rest upon the Zwartberg, and which form the base of the series which we know as the Karoo rocks. Now what those lower beds may be which intervene between Prince Albert and Zwartberg, I will not now stop to discuss, but I will say that just to the south of Prince Albert you come upon a marvellous rock which has amazed every one who has examined it, and defied the skill in interpretation of every one who has brought the powers of the microscope to bear upon it, and that rock we know as the Ecca conglomerate, which was sometimes called by your earlier geologists, (especially by Mr. Andrew Bain, that wonderful genius to whom we owe the first interpretation of the geological structure of Africa), the trap conglomerate, and presents the aspect of a trap on the one hand, and a conglomerate on the other. But when we come to consider what variance there is in these terms, that a trap means a lava flow forced out from a volcanic centre flowing over the surface of a country, and that a conglomerate means a rock rolled into the form of pebbles by the action of the breakers on shore, which boulders have subsequently been united by some kind of cement, you will see that the old name of "trap conglomerate" implies such a contradiction that in the interests of science we lay it one side, fully recognising the discrimination which recognised its true character, and we adopt the name "Ecca conglomerate" instead. Now by this term Ecca conglomerate, which I believe we owe to Mr. Dunn, we mean a rock in which you find rounded boulders and angular fragments of all kinds of rock, for the most part crystalline, and very frequently perfectly altered from their original condition, and embedded in a cement which resembles different forms of volcanic ash (ash such as that which was thrown out in the wonderful eruption of Krakatoa), which apparently fell upon a shore where pebbles and boulders were brought down in great quantity, and which have become cemented into a rock, which now, after the long lapse of ages, presents the aspect of a trap,

of a volcanic lava flow, owing to the manner in which its parts have been cemented together, so as to resemble a basalt. That Ecca conglomerate ranges through the Colony ; I have seen it here in the western part, I have seen it in the eastern part at Graham's Town, and it forms the base upon which the series of rocks rest which we know as the Karoo basin.

Having determined this base for our investigations, we proceeded northward, always, I may say, under the friendly guidance of Mr. Thomas Bain, who, knowing the country so well, saved me many and many an hour of what might have been fruitless wandering by so freely placing at my disposal the knowledge which he had gained in a life-time of work in the public service, and this journey northward brought us ever upon newer and newer layers of rock, which were not in a horizontal position, but they too had felt the effects of the great southern compression which had thrown the slightly-inclined deposits into undulation, so that I may say that south of the railway, which we struck at Prince Albert Station, between Prince Albert town and Prince Albert road, there are at least six great undulations of the rock, that is to say six bends downward, or synclinal folds, and the corresponding upward or anti-clinal folds, so that the folds succeeded each other in a manner that you may describe as parallel, the troughs and the saddles running east and west through the country in the whole of this area south of Prince Albert road. We found no fossils, but I am told that in the extreme east of this area, in the neighbourhood of East London, Mr. McKay has been fortunate enough to find some bones, which I have not yet had an opportunity of studying, in some of the lower beds which have hitherto proved unfossiliferous in the west. This is a matter that may be of some importance eventually, because all the lower part of the series has hitherto been regarded as forming a distinct group of rocks, separated, under a distinct name, but in so far as I can see from the structure of the beds themselves, or from their relation with each other, there is no character whatever by means of which the lower division, which has sometimes been called Kimberley shales, can be separated from the group known as the Karoo rocks. But as you leave the line of railway towards the east of Mr. Luttig's farm and Jan Willemsfontein, you pass bones, and these are the bones of large animals, sometimes to be seen in the roadway, which have been rolled down by the wagon wheels passing over the roads, and indicating animals fashioned in the main on the type of the common European Salamander, with comparatively long bodies, large rounded heads, moderate length of limb, but which vary in length and attain to something like 10 or 12 feet. These animals have been secured, I may say, almost entirely by the energy and peculiar skill in that kind

of work of Mr. Thomas Bain, and his collections have been sent partly to the British Museum, where they remained unworked and unnoticed for a period of 10 years till, on the retirement of Sir Richard Owen from his connection with the museum, I felt myself at liberty to turn attention to a branch of study which he had made peculiarly his own by the great contributions to knowledge which he had elaborated in relation to South African geology, and then I learnt the wonderful natures of the animals among which Mr. Bain's collections had been made. I have here some diagrams which may serve to give you an indication of the form of some of these animals but the diagram will give no conception of the size. This figure, in the transactions of the Royal Society of London, represents the upper and under sides of an animal which Sir Richard Owen had named the *Pareiasaurus bombidens*. It is, you will observe, known by its skull and vertebral column, the vertebræ being incomplete from the beginning of the neck to some distance down the tail; there are also parts of the bones connected with the shoulder's girdle, but very imperfectly preserved, so that we knew a little, but not much, of the apparatus by means of which the anterior limbs were supported; then there are slight indications of the ribs, and further on an indication of those bones of the hip girdle by means of which the hind limb was supported. Well, that figure is about one quarter the natural size, so that this animal, in the condition in which it is preserved, is something like 11 feet in length. We were very anxious to obtain better knowledge on this, as on the other kinds of fossil life, and as we travelled to the northward of Prince Albert-road Station, and entered the region of the Karoo rocks by the neighbourhood of Tamboer and the country which extends northward, to the Nieuveldt range, we found these *saurians* very widely distributed. The Dutch farmers, ever on the alert for natural history phenomona, had anticipated my coming, and at the first indication that we were likely to visit a certain spot, every specimen that could be in any way of interest to us was obtained, so that our labours were very much lightened. However, we were somewhat anxious on the score of this collection of specimens. For what has been done hitherto has been this: whenever a bone has been found, such as a skull, the skull has been taken away, and as the skull has been disconnected from the rest of the body, the consequence was that we found that there were about fifty skulls in the British Museum, and no indications of the bodies to which the skulls belonged, and so we were desirous of coming across the animal with which the skull might be connected, and we went on very well, owing to the friendly co-operation of a gentleman of Tamboer, Mr. John Marais, whose labours in the cause of science will, I am sure, receive full recognition hereafter. We had

the good fortune, owing to his help, of coming upon one of these animals complete, in the skeleton, just as it had been complete in the flesh, left upon the surface of the country, lying embedded in the rock and only needing to be taken out and carried away. This carrying away was perhaps a little more difficult than we in Cape Town had imagined. We were in the open veldt, where there is no possibility of getting assistance, where you have to hunt along the mountain side until you come to the bones of which you are in search; there are very few facilities for bringing away the specimens in the best possible condition, but owing to the aid which was never wanting and never grudged in the least, we were able to gather up the fragments, which filled several large cases, and a procession of mule wagons bore away what I trust will some day be one of the most prized ornaments of the British Museum in London. Why were we so anxious to carry away these? I will tell you. It was because the animals present in the external form of the skull all the characters of the frog tribe, all the characters of that low grade of amphibian life which we place below the reptile, display in the configuration of its shoulder girdle and of its hip girdle the characters of a higher mammalian type. We knew, as I say, nothing whatever of its limbs, and were anxious to contribute this element of knowledge in order to see whether there was that connection which seemed to be probable between the amphibian and the mammal, to see whether there had been a development of the higher mammal from the lower amphibian, without passing through the intervening grades of reptile and bird, and the result was that when the *matrix* was cleared away—and I may tell you it was no easy matter, for the rock was very hard—as the *matrix* was cleared away and the bones laid bare, and I secured them, I found to my amazement that although the proportions of the bones and the fore-limbs were extremely heavy, heavier perhaps than in any other known mammals, yet the forms of the bones were entirely mammalian. Let me say exactly what this means; there is, in the hinder and the lower end of the upper part of the arm, in what we call the *humerus*, a great cavity, into which a projecting bone of the elbow fits, which in England is popularly known as the funnybone, but which is correctly known as the *olecranon process* of the elbow which works into the cavity. Now no reptile shows that process, yet we found not only was that process developed in this animal of the Karoo fully, but as fully so as we find it in any mammal. It was fashioned exactly upon the mammalian plan. There was another point of great value and interest, which is this: in reptiles the *ulna* is usually the stouter bone of the lower arm, and the *radius* is the smaller bone of the fore-arm, whereas in mammals the reverse proportions obtain, and the *radius* is the strong bone and the *ulna* the more slender, so

that when I saw the *radius* was the stronger bone, I felt I could have interpreted the limb, if it had been brought to me whole and separate from the skeleton, as probably a mammalian limb. The time went on, and the sun rose higher ; we cleared away the hind limb, and I then had the pleasure of laying bare what was hitherto unknown ;—the bones of the ankle joints. Now there is absolutely nothing in the skeleton of an animal which is more instructive of the higher types of life than the condition of the ankle joints. In the reptiles, the ankle joints are for the most part two series of small bones, ranged in parallel series, in rows. When you come to birds, the structures are modified in consequence of the wonderful mode of progression of the bird, by hopping, in consequence of which a large amount of labour is done by the hind limbs, which result in a concentration of ossification as a result of which you find that the upper ankle bone is blended with the end of the drumstick, and the other with the metatarsal bones, so that there appear to be at first sight in the birds no ankle bones at all, but when you come to the mammal you find a much nearer approach to the reptile. The lower row consists of a series of small ossifications, while the upper rows usually consist of two or three bones. Now when I laid bare these bones to draw their contours, I found they presented forms which were of this kind :—here came the lower end of the bone, which forms the outer bone of the leg, which we term the *fibula* and here came downward the bone which forms the inner bone of the leg, which we call the *tibia*, and to my surprise there was a single great bone extending downward in this way, which passed underneath the lower end of the *tibia*, and which corresponded to the heel bone and pulling bone of the ankle, that is, corresponded to the *oscalcis* and *astragalus* blended together. Now this is a perfectly new type of ankle formation, and as the excavation went on, we found there were other bones indicating a lower row in this manner, and these came on the *metatarsal* bone, the bones of the *phalanges* succeeding, and we found that the feet terminated in great curved claws, so that although I only represent to you one digit, because there was only one undisturbed, owing to the action of the weather, yet from this we were able to make out the structure of the foot and prove that these animals were not only capable of swimming in the sea, but possessed that modification of limb which adapted them to move upon land. I should weary you if I went into detail as to the history of this particular animal, and I have only gone into the story of some of the points we have made as to the structure of the animal, because it serves as a type of those wonderful problems connected with the history of life upon the earth, with which your country teems. It contains riches on every side for the naturalist who will take the treasures as they lie near to the surface of the country ; and I will venture to say

that wonderful as are the remains of extinct animals which the old world has yielded in its northern regions, and wonderful as are those amazing collections which Prof. Marsh, by the expenditure of a princely fortune, has gathered together from North America, your country, within comparatively a few miles of Cape Town, is capable of yielding to any naturalist, with a moderate and judicious expenditure of money, treasures in a complete form of the extinct natural history of the country, which are not to be surpassed by any specimens in the world.

But I must now leave the *Saurians*, and pass on to some of the other discoveries which we made. On we went towards the north ; we passed through the Nieuwveldt range, passed that wonderful example called the Oude Kloof, and there saw what to me was perfectly new—a range of mountains which were nothing more than a gigantic range of hills—for you are aware that we are accustomed to define a mountain, or a range of mountains, as being a mass of rock which has been heaved up from the surface by compressing force, so that the structure of a mountain range always shows more or less of this plan :—rocks, originally horizontal, have been thrown together so as to be condensed and hardened,—but in the case of the hills we found that although the contour of the hills might closely approximate to that of the mountains, they consisted of masses of rock, which have not been materially disturbed from their original horizontal position ; they have never been folded, so as to leave the more durable beds in a compressed position. We thus say that the mountain has resulted from a process of compression and upheaval, whereas a hill is due to denudation. We saw this range seventy miles off ; saw it stretching clearly on the horizon along the Zwartberg presenting its flat, table-topped hills almost level, with jagged peaks, which bounded the horizon. I found, on coming upon it, that there had been no compression, no thrusting of the rocks at all, but that everyone of the layers which spread over the country we had been traversing was disturbed in comparison with the horizontal position of the beds of rock in the Nieuwveldt range, and this was marked ; the range which was perfectly unbroken, having been riddled and pierced and crossed with spider's web-like interlacings of volcanic rock. The rocks are very little disturbed by the upheavals to which they have been subjected, and there is not the crumpling of the rock to which we are accustomed in Europe. The result is that wherever a dyke is between two superimposed masses of sandstone or shale, it has resulted that in the long space of time in which this land has been moulded from the original state, so that the tidal waters came to wear the rock down, all the area which had been pierced by the old lava streams became durable, set up in a mass of jagged heads, the pieces

arising straightest where the lava spread most continuously ; and this is the history of the mode of formation of the range. Clearly an amount of wear has been carried on by the action of rain, &c., which has worn the softer clay, so as to leave the harder layers of sandstone jagged and standing out in masses on the slopes of the inclined plane. Well, as we went up this range, we recognised different zones in the Karoo rocks, as we went from the lower beds to the higher, and when I tell you that at the time of my leaving England, no one there had the faintest conception of there being any such divisions, no one knew whether any fossil which had been sent to England came from the lower or the upper beds of the Karoo, or whether it were possible to determine if there were lower or upper beds, you will see we were on the track of investigations which presented the possibilities of some great results, and we found as we passed upwards that the kind of life changed. We left these *saurians*, such as the *pareiasaurians* behind ; *saurians* which presented the semi-circular form of head, with the comparatively short tail, though not quite so short as that of the lizard, but which do not differ essentially from the type of the lower mammals at all, in proportion as we see in the *ornithorhynchus*, (which represents the lowest type of mammals laying eggs and suckling its young) with which we are acquainted. The upper beds of the rocks which we examined now began to yield to us *saurians* of a somewhat different nature ; the limbs were longer, the head somewhat different in form, and furnished with marvellous tusks, whilst the body was somewhat more arched in its contour ; the hind limbs were better adapted for walking on land, the tail apparently shorter than had been the case before, and these animals possessed tusks which at first sight resembled the tusks of the dog tribe—the type which came to be known as the dicynodon family, or the family of animals with the dog-like teeth. Now these occurred in the zone of rock which goes immediately above that which yields the large type of *pareiasaurus*. Going up higher still, we lose these large animals, for many of them were large, some with skulls almost rivalling the size of our largest terrestrial mammalia, and which pointed to another group of animals altogether, in which you will recognise a different type of teeth, as seen in the example before you. Here you see dicynodons in which are a single pair of tusks, lying at the side of the jaw, without any teeth in front or behind, but here you will observe that there are the tusks still, and in addition there are teeth, incisors, and teeth which correspond to our grinders, or molars. These are at the back of the jaw. Well, these showed the character of the rocks, and defined them, and the most important discovery we made perhaps, or at all events one of the most important, was that there is a succession of these types through

the whole of the Karoo rocks, up to the zone in which the coal is found, so that if a geological survey of your country should be ever made—and I may say that I can conceive of nothing more desirable in the interests of the population generally than such a survey—it would be possible to examine these rocks thoroughly and economically by means of the fossils to which I have referred. And see the importance of this. When we were on the flank of the Zwartberg, just at the base of the Karoo series, there were in the neighbourhood of Prince Albert some thin indications of coal beds, which were at the time in process of examination ; well, if those coal beds occur in the lowest zone of the country, in which we find vertebrate fossils at all, there is therefore the possibility of that seam at Prince Albert following on the line of country, and elsewhere proving more valuable, more useful, more capable of ministering to the wants of mankind, than is the case at Prince Albert. Now these newer coal beds present this character ; they are in the position in which the coal grew ; we were able to establish this in a very remarkable way. At one spot in the neighbourhood of Cyphergat we entered what had been once an open working, and there found the trees standing in the position in which they grew, with their roots still in the position in which those roots were extended through the life of the tree, the trunk of the tree being broken off. And this leaves a fact of extraordinary character, which I have never seen in any tree, either alive or fossil ; its roots presented when they were examined this detail an internal case which was divided by *nodes* in this way internal surface, and ribbed longitudinally, so as to present almost the character of the *calamites*, which is associated with coal throughout the greater part of the world ; externally was a covering which was thickened over the *nodes*, so that the external roots presented not a constriction, but a thickening in the position in which these *nodes* were situated ; and the character may perhaps, when I get into the land of scientific books once more, enable me to find out the nature of this tree, and throw some light upon it, as it is associated with coal in the other parts of the world. This was no isolated condition, for immediately beneath were the fragments of another tree so situated as to show that the tree had grown and had become broken off and accumulations of sand had set in over the country, the country had increased in range, and then a new forest had grown on top of the old one. The importance of this lies in the fact that your coal has hitherto been regarded as being, to a large extent at least, drift coal, which from its position has been swept along by moving water, and if so, your coal would be of accidental occurrence, not to be relied upon ; but if your coal has been under such conditions as that in which I found it, under the same condition as that in other parts of the world ; that is, if your forest tree has lived,

and then fallen so as to dam back the water which led to the growth of those water-loving plants which eventually became what we call bitumenised, then the growth of that matter gives you coal, which must be spread as far as that forest growth is to be found. Hence I have no hesitation in saying, and this is a scientific fact of some importance, we found about the coal on the horizon of which these fossil trees occur, enormous ferns beautifully preserved, as fresh as those we had just seen, with the details of structure perfect when first laid bare, but rapidly dissolving away when exposed to the warm temperature of a room, and we found that, in specimens brought to us from the Indwe locality they were united into a compact mass by a siliceous cement. When I tell you that in the neighbourhood of Colesberg we found forest trees mineralised with silica so that frequently there were many trees lying parallel to each other, all converted into this substance, and when I further say that the record which the farmers gave was that at a few feet beneath these trees they came across a black substance, which burnt—they had no name for it—it cannot be denied that there is a relation between the occurrence of these trees here reserved in sandstone, and those trees which I have referred to in the Colesberg country, which are converted into silica. That connection establishes this fact, that over the country you will find spread a layer of coal, and near that coal vegetable matter, which did not last sufficiently long to permit of its growth to form another layer of coal, of stronger coal, on a higher level, but the occurrence of these silicates, by their obvious character upon the surface of the country, point to the coal which grows beneath, and when we went northward, after having made this travel through this country up to Fraserburg, we extended our course eastward, and set to find as far as we could the northern limits of the rocks which contain the coal. We found we had never anything to rely upon when we got away from the region which yielded our bones, and so, stopping at Aliwal North, one of the most northern points of the Colony, which borders upon the Free State, we had the good fortune to come upon one of Nature's born naturalists,—a gentleman who has devoted his life to the study of living and fossilised reptiles, Mr. Alfred Brown—who showed us the specimens he had collected during some twenty years and took us to the locality from which they were obtained, and these reptiles proved to be several examples of those theriodont reptiles which we could only compare to the mammalia, and I have very little doubt some of them would prove to be true mammals. They possessed teeth, with all the elaborate modification of formation which we find only in the higher warm-blooded animals which suckle their young, but there were a number of others which I feel sure are reptiles allied to the *lyco-*

saurus. I have here something to represent at least one of these mammalian characters, and although these are new and I can therefore give you no name for them, they served afterwards to aid us very materially in our investigations ; because, as we got on and had the pleasure of seeing specimens collected by Dr. Kannemeyer, (who has been a liberal contributor to the Cape Town Museum,) we found tha the too was upon the zone in which these mammal-like reptiles occur, and then, when we went further south still to Queen's Town, there we found exactly the same forms as those which occur at Aliwal. We were told they came from Lady Frere, and accordingly the horses were put in, and away we went to Lady Frere, because we were told that these things occurred just below the Indwe coal-field. Now this is a point which would suggest that coal should be looked for in the country between Queen's Town and the Orange River, and it meant that if by this means we had come upon the beds of the Indwe coal, we may very well look for the northern extension of that coal, for the beds of coal in which we found these mammal-like animals—and here I say that if science is able to furnish a grammar so to speak by means of fossils in this way, it only needs the organisation of these laws to prevent the waste of money by fruitless search for the treasures which the earth contains, and obtain at the least possible cost the wealth with which the earth teems, to those who seek those precious results.

Now having sought thus for the history of the gradations of life as they were distributed, and found that inseeking the history of life we came upon matters of practical importance in the way of coal, it became desirable to gather up, somewhat more fully than we had done hitherto, the story of the structure of the animals which had came to our hands ; and when we took the skulls of these wonderful animals which Dr. Kannemeyer had collected and we found subsequently that he had presented to the Albany Museum at Graham's Town, we found also that, reptiles though they may be, they had lost all the distinctive characteristics in the skull of the reptilian, with one or two possible exceptions that we could not examine into, and had acquired in other cases the character of the skull of the mammalia. Even in the form of a crocodile's skull were those typical characters of the mammalian skull seen, which distinguish it from other types by the way in which the lower jawbone is united to the wall of the brain case by the *squumosal* bone. We know that in between the *squamosal* bone and the lower jaw there is a large bone called the *quadrate* bone, occupying an intervening position. In birds you find there is a bone of this kind, which fits into a cavity at the side of the skull, behind the eye, which acts perfectly freely, and which gives attachment to the lower jaw. In the reptile

there is exactly the same bone, and you call it, as I have said, the *quadrate* bone, and when you come to these fossils of South Africa, the *theriodonts* which lie immediately beneath your coal, you can see no quadrate bone at all, because the *squamosal* bone, with which it articulates, grows down, hides it, and obliterates it. Now if you will examine the mode of articulation in the mammal you will find there is nothing whatever between the lower jaw and the *squamosal* bone, and it is precisely the same in the fossil animals, though of totally different structure of skull and mode of union of the lower jaw with the skull, two distinct types of the mammal kingdom being here represented. The one, the *theriodont*, has teeth like the dog, and the other, which has two long teeth, we term the *anomodontia*, and these two orders of animals are the orders which furnish the bulk of the fossil life which found spread over the Karoo rocks.

Now I have spoken thus far upon the bones, and a few of the problems connected with them, but there are yet higher beds of rocks that I have not had the opportunity of examining: those which contain reptiles, extending far into the northern part of the Colony and into the Free State; such, for example, as the example in Cape Town Museum, which shows a small animal of the same family as these reptiles, but very much more on the plan of those which occur in the *triassic* rocks of Germany and the secondary rocks generally of Europe, and although it had a tusk, I have been able by impressing a substance in which the mould reproduced the form of the bones so that the configuration of the skeleton can easily be made out; frequently we have been obliged to adopt this method because the bones of the animals have been dissolved, but the tusk yields the evidence of the structure of the animal. Now when we turn from these most interesting matters concerning the history and evolution of life and the distribution of coal through the country, we have by no means exhausted those matters of interest which come under our notice. One of the problems which we imposed upon ourselves at starting was to examine upon such occurrences of gold which came in our way, and I may mention, as the papers have already done so, that we visited Cradock, and also Barkly. I am not going to tell you exactly what we found, because the details of the examination belong to the Government, but the scientific facts we found are the property of science, and the general principles of the occurrence of gold I may allude to, because it opens a new chapter, so far as I am aware, in the history of science. We went to Cradock and examined a number of workings, some in the immediate neighbourhood, and some at a greater distance, and we found that in some cases people were working intrusive sheets of lava, under the impression that they had got the gold reefs, and in other places they were

working a kind of rock quite different to the masses of prehnite in the country which occur in the curious V-shaped troughs, spread over the surface of the land. Well, these things were so extraordinary that they called for very careful examination, and we found that spread over the surface of the land in that district you have volcanic rock, and this volcanic rock has yielded on its decomposition, as a volcanic rock does, a mineral or minerals which consist essentially of decomposed felspar. All volcanic rocks are thus decomposed, and re-crystallised in combination with a certain amount of water. Wherever the rock is porous, this mineral has entered, with the result that you have a network and nests of occurrences of the mineral, spread through the volcanic rock. Now we are not able to give you the estimate of the quantity of this prehnite, but I may say it is a result of the decay and decomposition of the felspars in the volcanic rock spread over the country. I do not mean to imply that it is a type of the existing surface of the country, but what I would wish you to realise is this, that in the sea water you have at the present day sea weeds, which sea weeds separate from the sea water a great many mineral salts ; as those sea weeds decay, the mineral salts are deposited on the bottom, and you may be aware of the extraordinary fact that a ship sailing through the ocean collects upon its copper bottom a deposit of gold, which is obtained from the ocean. Well, these salts, which are separated in the sea, come to be embedded in the rock, and when, in process of time, these rocks are compressed a great depth beneath the surface, and are raised in temperature by the compression, and subsequently burst away upwards through the fissures produced by the foldings, which become dykes, they are poured out as lava sheets, the lava contains the sediments from which they were formed. When, subsequently again, the land which contained these varied mineral salts comes to undergo decay and decomposition, under the effects of the atmosphere, so that enormous thicknesses of rock are cleared away, and nothing but heavy insoluble substance is left at the surface, it results that while many other things are washed away, the gold, if it were originally contained in the rock, is left behind. Although I am not able to tell you the probable quantity of the gold at Cradock, I may say that the gold is there, but not in the *prehnite* in sufficient quantity to make Cradock a rival to the Transvaal just at present. When we went into the neighbourhood of Barkly, we found something new, most interesting to us, in relation to gold ; we brought away specimens to analyse, and the analyses will eventually be placed before you, but I may now mention this, that while a great many of the layers of quartz which are commonly called reefs, which are deposits of quartz, were found to contain gold in combination with iron pyrites, most extraordinary circumstances were associated with some of

the intrusive sheets of lava, in which, in some instances, substantial traces of gold were found, and this led us to the thought of whether it would not be a matter of the greatest importance to survey the whole of the sheets throughout the country, so as to ascertain which are really valuable, and capable of mineral wealth, and which are worth marking off so as to be avoided.

Now our studies of gold led us to travel over a great deal of country which was badly in want of water. I am sorry to say that not only was the land impoverished for want of water, as very much of the land we traversed frequently had had no rain upon its surface for something like a year, and when after this long period rain came, frequently periods approximately from threequarters of a year or more would pass without rain again, yet I could not but reflect that there were two or three things to be borne in mind in relation to the geological structure of the country. In the observations which we had made much might be properly utilised by means of a geological survey of the country, which would be of greatest value. For example, wherever rocks are folded in the manner in which we found them to be folded in anticlinal and synclinal folds over the whole of the land every basin of this sort necessarily absorbs the rain which falls upon the edges of the rock ; water, then, is stored beneath the surface, and yet there is none at all upon the surface of the land itself. The rocks beneath the surface are as full of water as they can hold, and while the cattle on the farms are dying for want of water while the land is parched up so, yet there is water in abundance beneath the surface. This is pretty well-known to every geologist all over the world, and I may mention that the Government of Victoria, in Australia, have for a long time past made maps, in which they have marked down every well which was known in the Colony, for Victoria has a climate not altogether unlike your own, as the evaporation is greatly in excess of the rainfall, and the water under the ground has to be utilized, and so borings are made. The structure of the country makes it desirable to undertake such work, and when such a survey of this country is made, then every farmer will readily appreciate the position in which the structure of the country enables him to relieve his pressing necessities by tapping these springs. There is another source of water supply which Mr. Bain fully appreciated by observing the conditions of irrigation, which I may say he was ever alive to as we journeyed over the country, and that is the fact of these intrusive sheets of rock which you may see all all over the country, acting as a natural dam, a subterrannean dam, so that if you have all the rocks possessing this common feature of contour, horizontally, if you have an intrusive sheet of lava making its course to the east, it is perfectly clear that all the rains which fall upon these rocks

are obstructed by the sheet of lava, so that it is unable to flow down this inclined plane and all that is necessary is to find a suitable spot where this natural dam can be utilised with the view of yielding a permanent water supply for a large area of country, and without doubt it is of the highest importance that these dykes, when they hold back water, should be used in a proper and practical manner. If this be done, a water supply is assured for the benefit of the country. Now there is one other matter in the way of regulation of water supply which strikes me as important, and it is this, that I have observed in England the extraordinary fact that in the early morning in winter, soon after the frozen dew drops from the trees fall upon the ground you find accumulated beneath the tree a mass of material like hail, which is a measure of the quantity of moisture which the tree condensed from the air on the previous evening, and I have observed that when the air has been saturated with moisture, that the tree condenses so much that the water drains away from the tree in a continuous rill. If a tree then condenses moisture in this way, the moisture necessarily helps to saturate the rock beneath, and I take it as a fact beyond all question, after looking over various parts of the Colony, that so far as I am aware, without restriction, everywhere the farmer allows his trees to be barked, with the result that the trees die and the whole of the moisture to the land which the trees have been in the habit of drawing, is ended from that moment. The trees no longer possesses leaves which had caused the condensation of rain. The farmer is prepared to sell his trees as a matter of business, and is prepared to sell as many as seventy trees for the price of a single sheep, the consequence being that if you take it, at this rate, in ten years 700 trees have gone, and the moisture has gone with them. Well, the land has been destroyed in this way by the ruthless, thoughtless cutting down of trees, and unless some law to the contrary be enforced, many parts of the country will be converted into the ruinous condition in which you find it round about Colesberg, where I was told the country was formerly clothed with the wild olive, and there were so many trees you could not see a bare rock at any time, whilst now all is barren. Wherever trees are planted water will accumulate, and once this fact is fully recognised my belief is that the public spirit of the people of the Colony would enforce the planting of trees as a condition of universal prosperity.

Now these are the subjects upon which I have been engaged; bones, coal, gold, and water supply, these were the four great ideas in which the observations I have made seemed to gather into a focus. I came out seeking nothing but bones, I am now quite enthusiastic with regard to the condition and welfare of your country, and I am so far enthusiastic, that I venture to say, if this country is to prosper

in the way in which I should like to see it prosper, for it is really a beautiful country, a glorious country, as anyone who has seen so much of it as I have will fully recognise, if it is to prosper in the way in which I believe every inhabitant of it desires it to prosper, it can only be by the more full and universal utilisation of science in the service of man, and one of those lessons which science seems to me especially to enforce is that we have now found a means of marking down upon charts, which would become readily intelligible, a few cardinal facts of the geological structure of the country, and these charts will mark the area over which profitable industries may be carried on, and will in the long run, be a large saving of labour and money, and lead to the initiation of new industries which depend upon the minerals which obviously lie close at hand, as consequence of the distribution of gold, coal and water (applause.)